Forum for Electromagnetic Research Methods and Application Technologies (FERMAT)

Transmission Line Teaching Aids Using Slow-wave Transmission Line Technique

Guan-Lin Chen, Yu-Ying Li, Yu-Xuan Wang, Zuo-Min Tsai
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2015/7/2

Abstract: This paper proposes a novel transmission line teaching aids using slow-wave transmission line technique. This teaching aids can help students observe the behavior of the electromagnetic wave in transmission line directly. This direct observation is important for the undergraduate who just study electromagnetics because the behaviors of the transmission line are abstractive, and hardly to be imagined. The proposed slow-wave transmission line is concatenated with multi large inductances and capacitances. By using LED lights, student can easily observe the behavior of the forwarding wave and the standing wave in the transmission line. The teaching aids can help the students understand the behavior of the electromagnetics wave in the transmission line effectively.

Keywords: Teaching aids; slow wave transmission line; naked eye; forward wave; standing wave.

References:

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Zuo-Min Tsai was born in Maioli, Taiwan, in 1979. He received a B.S. degree in 2001 from the

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Outline

- Motivation
- Implementation
- Laboratory design
- Course outcome
- Conclusion

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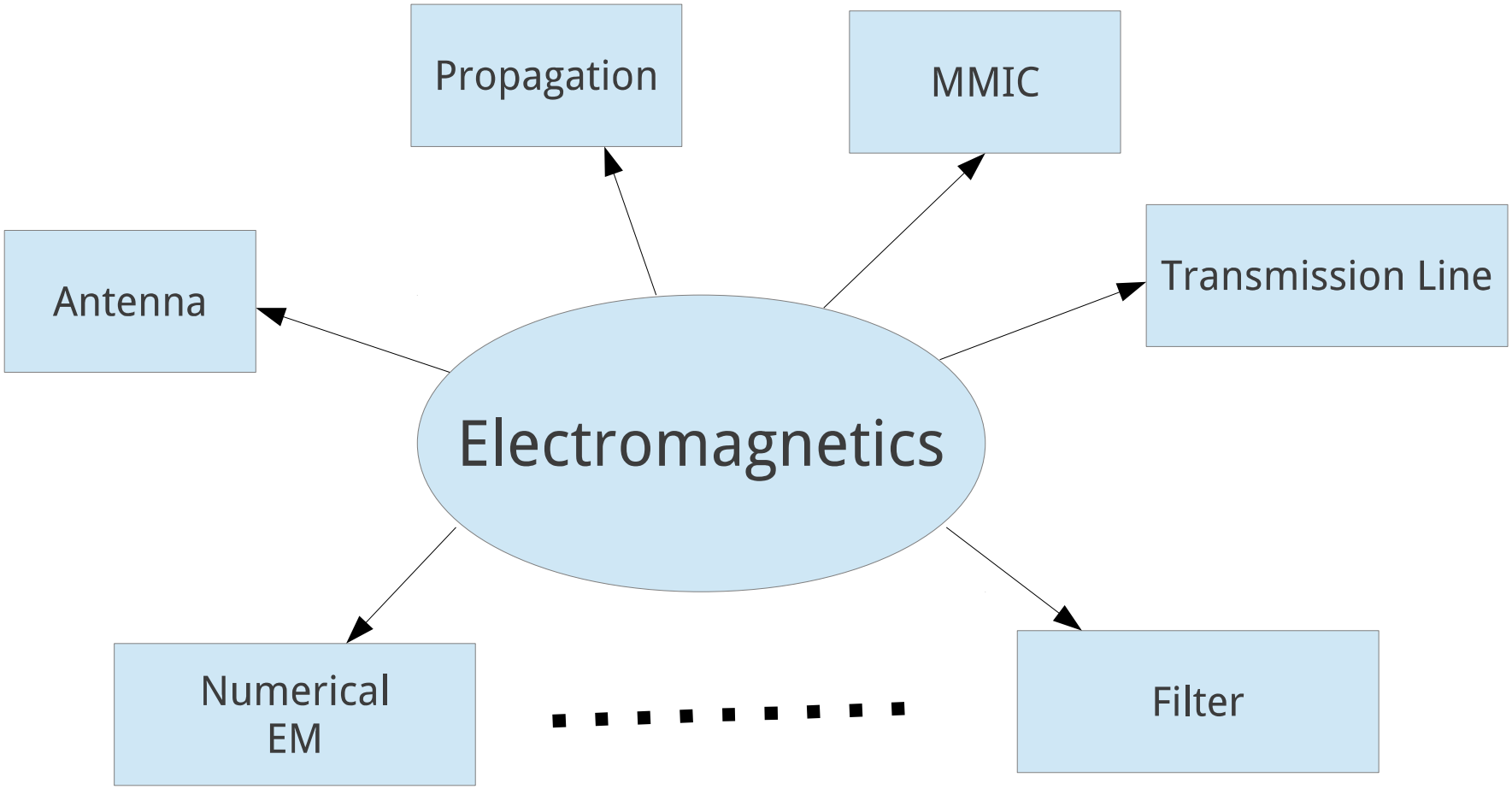
Study Goals of Electromagnetics

- Electromagnetics is the fundamental of lots of topics

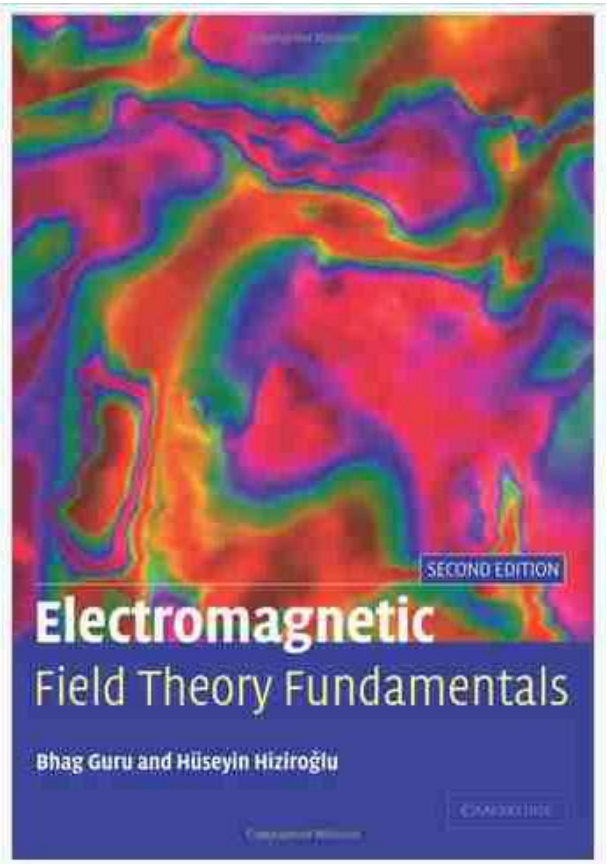


Barrier While Studying Electromagnetics

- Observation from university students in EE field in Taiwan
- Barrier1: Vector calculus
  - Gradient, divergence, curl
- Barrier2: Wave concept
  - Planar wave, transmission line theory

Organization of the EM Text Book Used in CCU

1. Electromagnetic field theory
2. Vector analysis
3. Electrostatics
4. Steady electric currents
5. Magnetostatics
6. Applications of static fields
7. Time-varying electromagnetic fields
8. Plane wave propagation
9. Transmission lines
10. Waveguides and cavity resonators
11. Antennas
12. Computer-aided analysis of electromagnetic fields



Organization of the EM Text Book Used in CCU

1. Electromagnetic field theory
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7. Time-varying electromagnetic fields
8. Plane wave propagation ← Barrier2: Wave concept
9. **Transmission lines** ← Basic of topic like MMIC transmission line, filter
10. Waveguides and cavity resonators
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12. Computer-aided analysis of electromagnetic fields

Study Goals of Electromagnetics

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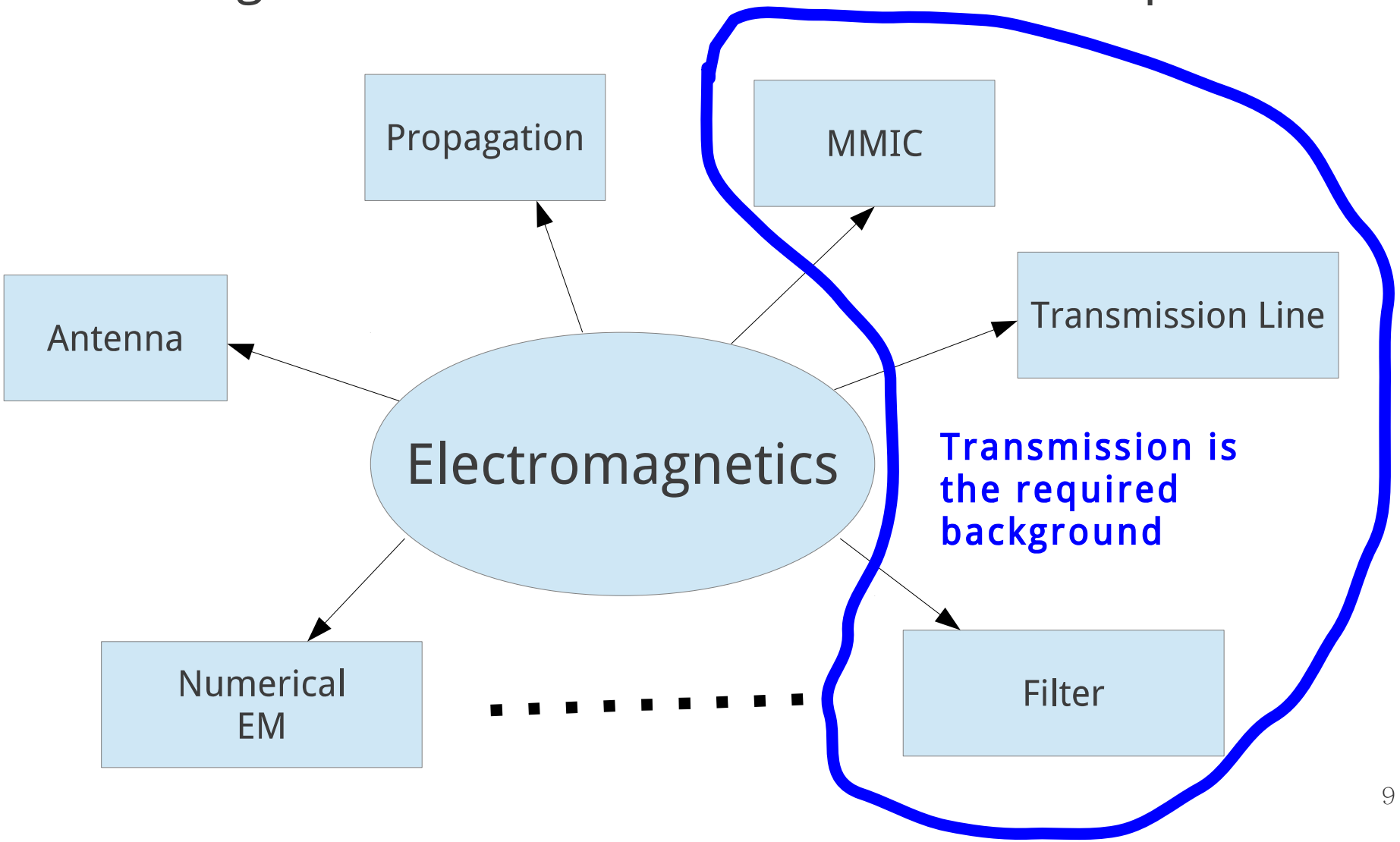
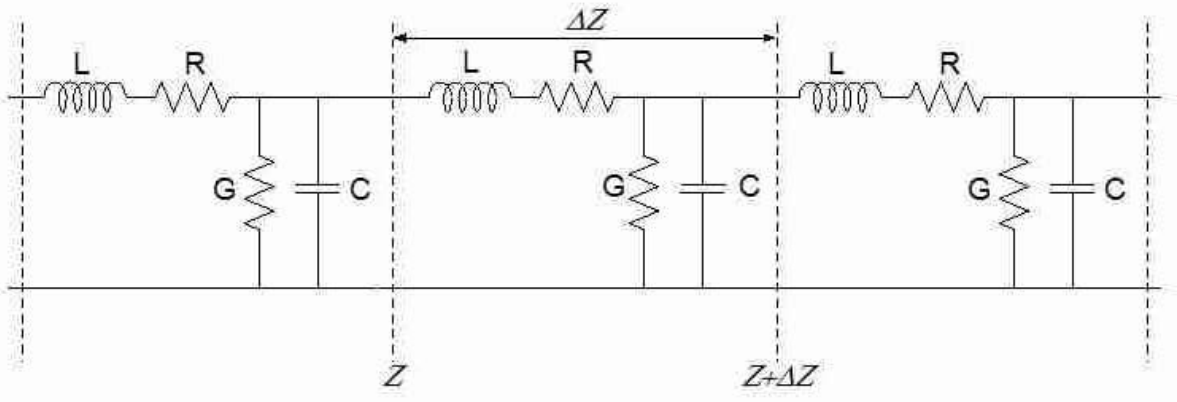
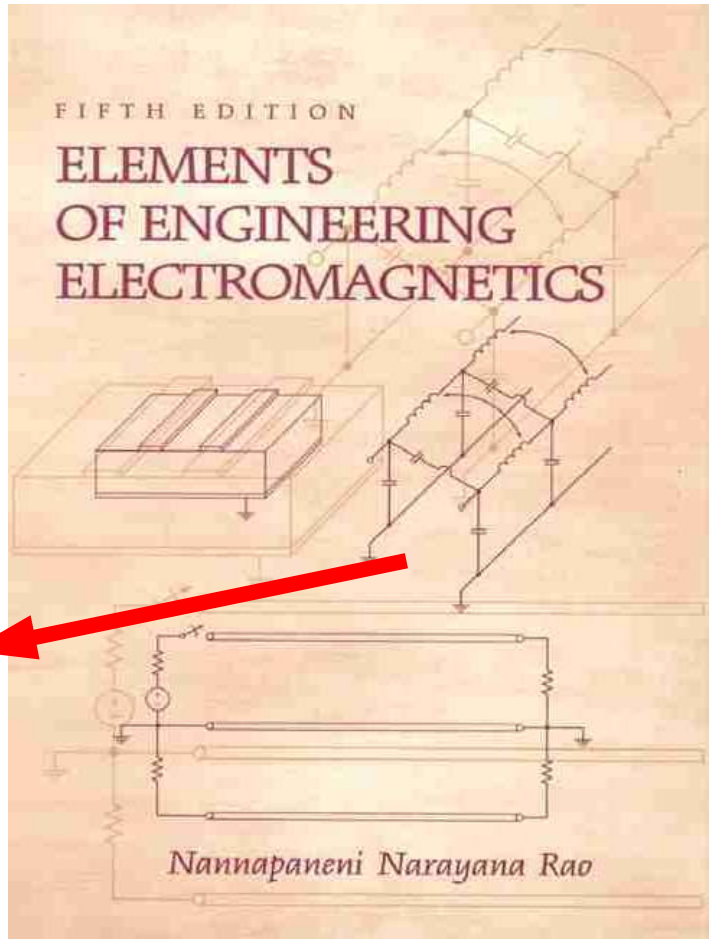


Teaching Transmission Line without the Two Barrier

- Use RLCG equivalence model
- Treated as the extension of circuitry
- Can be introduced before vector analysis (skip Barrier 1 & 2)





Used in NTU

Motivation

- Observation
  - Treat transmission line theory as an extension of circuitry can skip the barrier
  - Circuity laboratory is mature and helps student to understand
  - EM lab is started from the propagation, waveguide (students still meet the barriers)
- Question
  - **If I build a ''Circuity like'' laboratory, will it also help students to understand ?**

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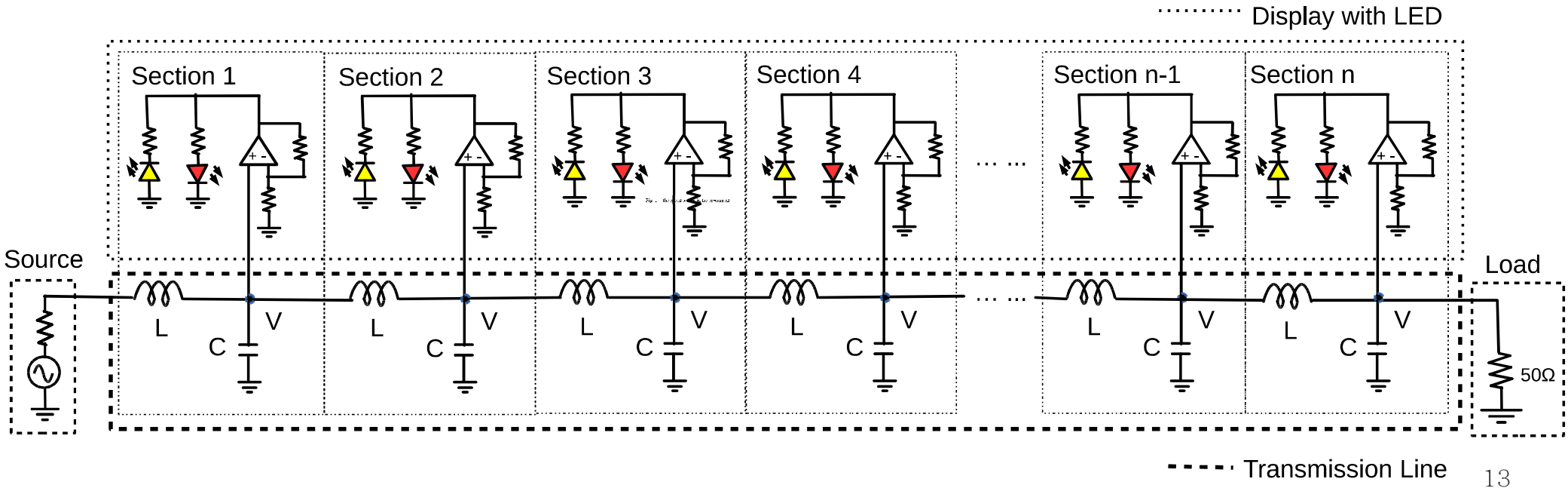
System Concept

- Use high L (1H) and C (470pF) to slow down the wave speed for the observation
- OP is applied to amplify the voltage and drive LED
- Red LED is for positive voltage, yellow LED is for negative voltage



Circuit Photo

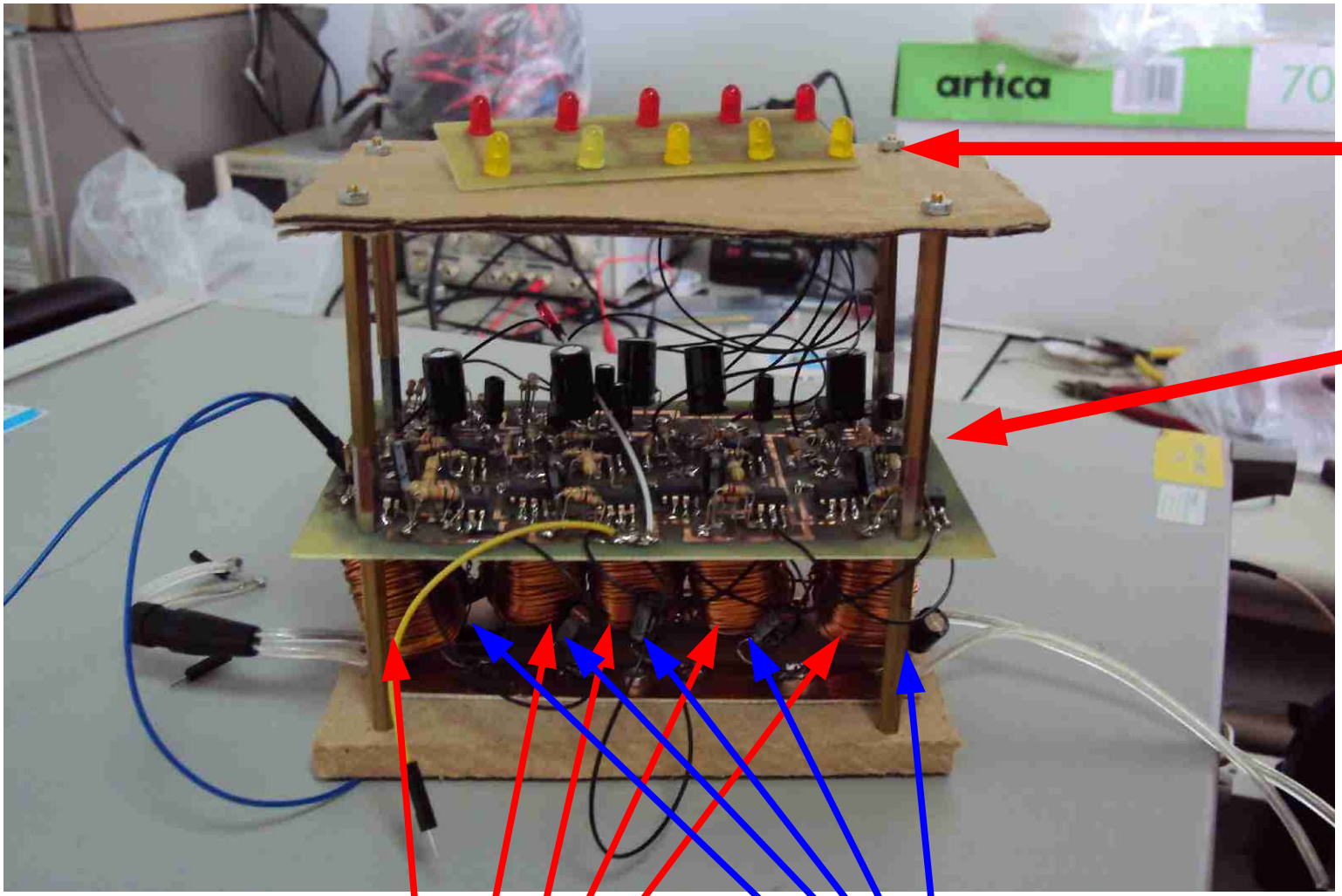
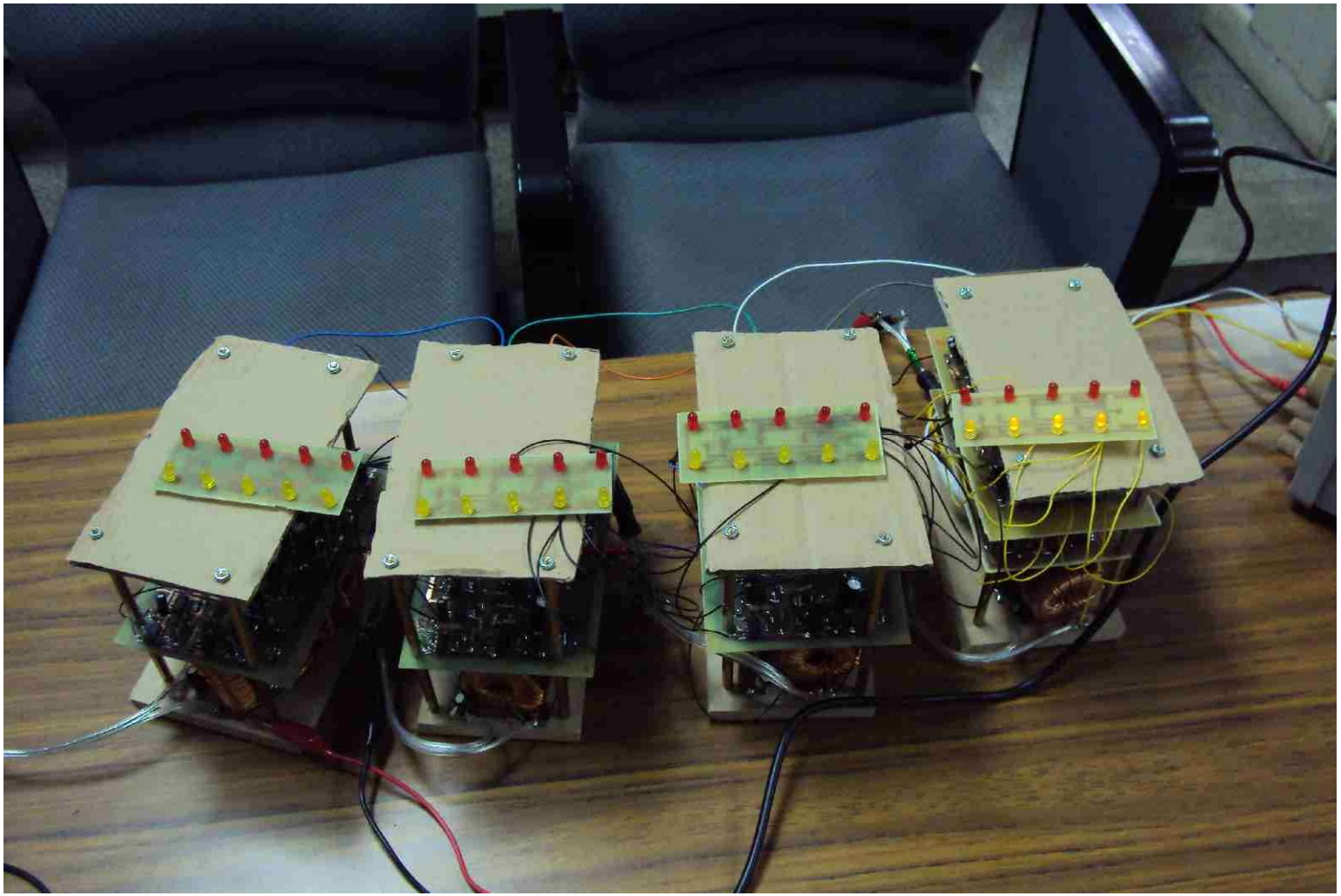


Photo of Cascade Operation



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Contents of Transmission Line in Text Book

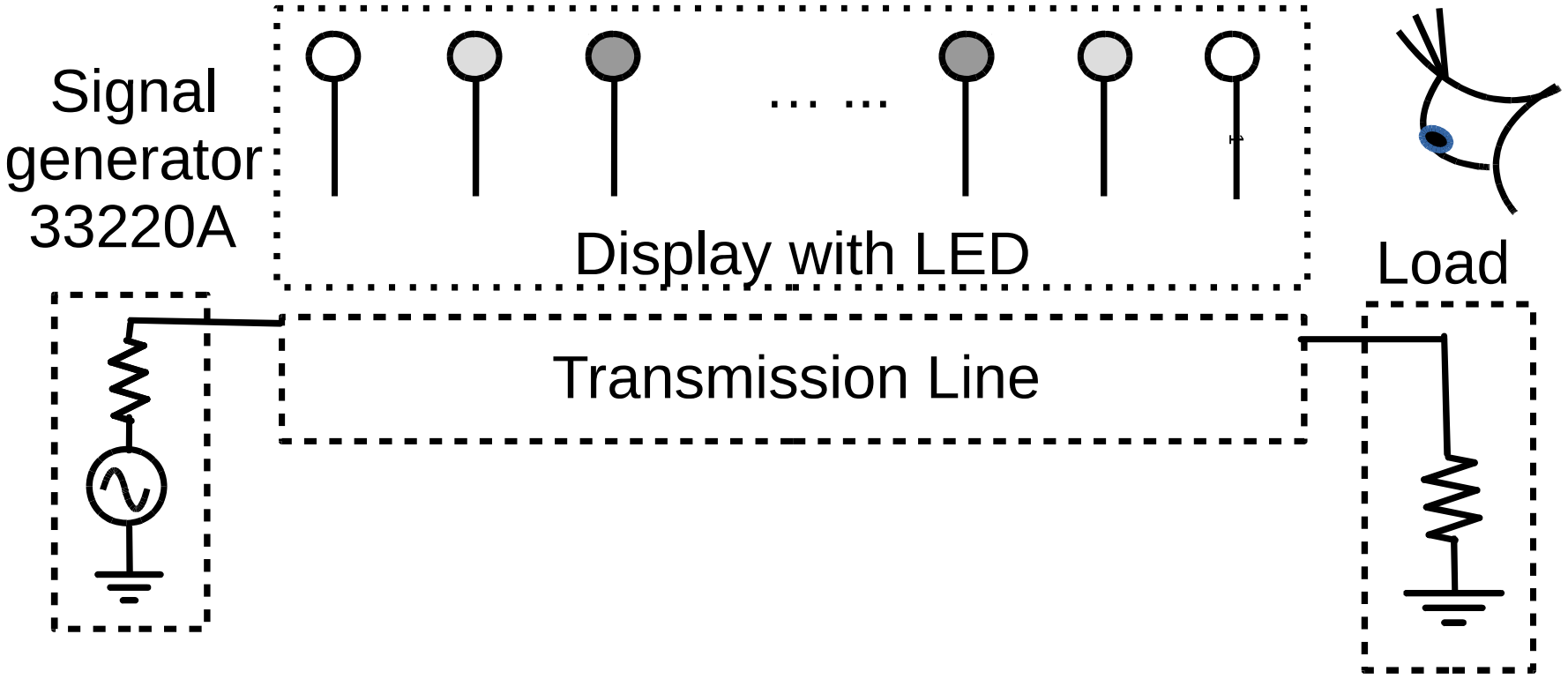
- RLCG model
- Forward and backward wave
- Impedance and reflection
- Standing wave
- Shunt stub and impedance matching
- Transients in transmission lines

Contents of Transmission Line in Text Book

- RLCG model (Calculation)
- Forward and backward wave (Lab1)
  - Frequency, wavelength and speed
- Impedance and reflection (Lab2)
  - Change load impedance to change the reflection
- Standing wave (Lab3)
  - Node and antinode
- Shunt stub and impedance matching (Lab4)
  - ¼ λ behavior (not yet ready)
- Transients in transmission lines (Lab5)
  - Step function, and pulse function

The Required Instruments

- Singal generator 33220A



Demonstration

Lab1 : Forward and backward wave (Lab1)
Lab2 : Impedance and reflection
Lab3 : Standing wave
Lab5 : Transients in transmission lines

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Laboratory Outcome

Workshop for
Chaiyi senior high school
Students

Workshop for
CCU University students

Laboratory Outcome

Workshop for
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Workshop for
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Both assessments are positive

Conclusion

- Treat transmission as the extension of circuitry could skip the barriers (vector analysis and wave concept)
- A circuitry-like laboratory is proposed
- A course using this laboratory is designed
- Workshops are held to test students' response
- Positive assessments is achieved